SULFIDE REMOVAL FROM PETROLEUM REFINERY WASTEWATER USING *Pseudomonas putida* (ATCC 49128) AND *Bacillus cereus* (ATCC 14579)

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Hidrogen sulfida (H_2S) dikenali sebagai salah satu daripada bahan pencemar berbahaya dari air sisa penapisan petroleum (petroleum refinery based wastewater, PRW), yang dilaporkan dalam kes persekitaran dan ekonomi, di samping komplikasi kesihatan terhadap manusia. Sifat semulajadi heterogen PRW berserta kekurangan pendekatan klasik mitigasi fizikokimia menjadi sebab pencarian alternatif yang efektif kos dan endah alam sekitar dengan kesan negatif yang minimum. Kultur bakteria bercampur (bacterial mixed culture, BMC) terintegrasi baru, *Pseudomonas putida* (ATCC 49128) dan *Bacillus cereus* (ATCC 14579) dengan kebolehan biodegradasi terhadap PRW kompleks dan berkepekatan tinggi dicadangkan sebagai alternatif pengoksidaan sulfida yang mampu menangani kekurangan tersebut. Kesan saling melengkapi tersebut mungkin menjadi punca toleransi terhadap kesan rencatan H_2S. Untuk permulaan, kesan kepekatan nutrient dan keadaan fizikal operasi lain iaitu suhu, pengadukan, dan masa aklimatisasi terhadap pertumbuhan pencilan tersebut disaring dan seterusnya dioptimum di dalam kelalang goncang dengan bantuan perisian Design Expert. Berdasarkan keadaan pertumbuhan optimum, bandingan RE BMC berserta kultur tulen dijalankan menggunakan air sisa disimulasikan pada kepekatan berbeza (200, 300 dan 500 ppm). Nilai RE model kultur tulen dan bercampur didapati pada 95%–100% dengan menggunakan air sisa disimulasikan dalam kelalang goncang. Walau bagaimanapun, nilai RE mantap ditunjukkan oleh model terpilih (BMC) dengan nilai RE tertinggi pada 99% bagi 500 ppm S^{-2} dalam tempoh 24 jam HRT. Tambahan lagi, kesan bersinergi parameter proses kultur kelompok terhadap pengoksidaan sulfida menggunakan BMC dioptimumkan melalui kaedah statistik menggunakan kaedah reka bentuk komposit pusat berpusatkan muka tiga aras (face-centered central composite design, FCCCD) dan kaedah permukaan gerak balas (response surface methodology, RSM). Nilai RE tertinggi pada 91% dicapai melalui model BMC pada parameter proses yang optimum 500 ppm, 0.5 vvm, 30 °C, dan 140 rpm masing-masing bagi kepekatan sulfida influen, pengudaraan, suhu, dan pengadukan, dalam tempoh 8 jam HRT. Tambahan pula, keupayaan biodegradasi sulfida oleh BMC disahkan menggunakan PRW sebenar berdasarkan parameter optimum dengan nilai RE yang tinggi pada 98.76%–99.75%. Sebagai kesimpulan, dapatan kajian ini dapat mengisi kelompongan berkaitan pengoksidaan sulfida dalam PRW rekalsitran secara biologi oleh model BMC baru dalam bioreaktor kultur aerobik kelompok skala makmal. Untuk itu, keandalan dan kebolehan peramalan model endah alam sekitar ini adalah sesuai untuk merawat air sisa sarat sulfida dengan potensi keupayaan RE yang maksimum.

ABSTRACT

Hydrogen sulfide (H_2S) has been recognized as one of the hazardous pollutants from petroleum refinery based wastewater (PRW), with reported cases of environmental and economic challenges, besides other human health complications. The heterogeneous nature of PRW couple with the documented shortfalls of the classical physicochemical mitigation approaches was behind the quest for a cost-effective and eco-friendly alternative with minimum adverse effects. A novel integrated bacterial mixed culture (BMC), *Pseudomonas putida* (ATCC 49128) and *Bacillus cereus* (ATCC 14579) with traceable imprints in biodegradation of high-strength PRW proposed as a suitable alternative sulfide oxidation approach with a potential solution to the shortfalls. Their complementary helper effects could be the reason behind their tolerance to the H_2S inhibitory effect. Initially, the impact of nutrient concentration and other physical operating conditions of temperature, agitation and acclimatization time to the isolates growth were screened and subsequently optimized in shake flasks with the aid of Design-Expert software. Based on these optimized growth conditions, relative removal efficiency RE of BMC along with the corresponding pure cultures were carried out using simulated wastewater at different concentrations (200, 300 and 500 ppm). The RE of the pure and mixed-culture models was found to be 95%–100% with simulated wastewater in shake flasks. However, a sustained RE was displayed by the selected model (BMC), with the highest RE of 99% in 500 ppm of S^{-2} within the HRT of 24 hours. Furthermore, the synergistic contribution effects of the batch culture process parameters on the BMC sulfide oxidation were optimized at three coded levels using face-centered central composite design (FCCCD) and response surface methodology (RSM) statistical tools. The highest RE of 91% was obtained with the BMC model at optimum process parameters of influent sulfide concentration, aeration, temperature, and agitation of 500 ppm, 0.5 vvm, 30 °C, and 140 rpm, respectively, within 8 hours of HRT. Moreover, the sulfide biodegradation capability of BMC was validated using the actual PRW based on the optimum parameters which resulted in overwhelming RE values of 98.76%–99.75%. Conclusively, the findings fill in some gaps concerning the biological sulfide oxidation from recalcitrant PRW by a novel BMC model in a lab-scale batch culture aerobic bioreactor. It suggested that the reliability and prediction ability of this eco-friendly model is therefore suitable for treating high-strength sulfide-laden wastewater with potential capabilities of maximum RE.

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LISTS OF SYMBOLS

L/min	Liter per minute
vvm	Vessel volume per minute
^{o}C	Degree Centigrade
rpm	Revolution par minute
hr	hour
ppm	Part per million
mg/L	Milligram per liter
$wv-^{1}$	Weight-volume
vv^{-1}	volume-by-volume
keV	Accelerating voltage
X_t	Cell biomass at time t
X_0	Initial cell biomass
ln	Natural logarithm
log	Logarithm
S_t	Sulfide concentration at time t
S_0	Initial sulfide concentration
$\triangle S$	Change in sulfide concentration
e	exponential
μ	Specific growth rate
t	time
β	Beta

LIST OF ABBREVIATIONS

ACWW	Actual Waste Waster
AGWW	Augmented Waste Water
AC	Activated Carbon
AD	Anaerobic Digester
AF	Accuracy Factor
ANOVA	Analysis of Variance
APHA	American Public Health Association
ASFBR	Anaerobic Structured Fluid-Bed Reactor
ATCC	American Type Culture Collection
ATSDR	Agency for Toxic Substances and Disease Registry
ADP	Adenosine diphosphate
AMP	Adenosine monophosphate
APAT	APS: Phosphate adenylyltransferase
APS	Adenosine 5’ phosphosulfate
ATP	Adenosine triphosphate
BAS	Biofilm airlift suspended reactor
BF	Bias Factor
BIS	Bureau of Indian Standard
BMC	Bacteria Mixed Culture
BOD	Biological Oxygen Demand
BRT	Batch reactor Type
BTEX	Benzene, Toluene, Ethylbenzene and Xylene
BSO	Biological Sulfide Oxidation
COD	Chemical Oxygen Demand
C_{O2}	Oxygen Concentration
CSTR	Continuously Stirred-Tank Reactor
CDW	Cell Dry Weight
CV	Coefficient of Variability
DSU	Desulfurization Unit
DF	Dilution Factor
DMDS	Dimethyl disulfide

DoE	Design of Expert
DSR	Denitrifying Sulfide Removal
DO	Dissolved Oxygen
DOE	Design of Experiments
EC	Electrical Conductivity
EDXS	Energy Dispersive X-ray Spectroscopy
EBRT	Empty Bed Residence Time
FFD	Fractional Factorial Design
FCCCD	Face-Centered Central Composite Design
HSPs	Heat Shock Proteins
HRT	Hydraulic Retention Time
HS^-	Hydrogen Sulfide Ion (Bisulfide)
H_2S	Hydrogen sulfide
IDLH	Immediately Dangerous to Life or Health
ICMR	Indian Council of Medical Research
LOAEL	Lowest-Observed-Adverse-Effect Level
MABR	Membrane Aerated Biofilm Reactor
MDU	Microaerobic Desulfurization Unit
NISDWR	National Interim Secondary Drinking Water Regulation
N	Nitrogen
NA	Nutrient Agar
NB	Nutrient Broth
NIOSH	National Institute for Occupational Safety and Health
NO_3^-	Nitrate
OFAT	One-factor-at-a-time
OVAT	One-variable-at-a-time
OLR	Organic Loading Rate
OTR	Oxygen Transfer Rate
OUR	Oxygen Utilization rate
ORP	Oxidation-Reduction Potential
O_2	Oxygen
OEL	Occupational Exposure Limit
OD	Optical Density

OSHA	Occupational Health and Safety Agency
PRW	Petroleum Refinery Wastewater
PEL	Permissible Exposure Limit
PAH	Polycyclic Aromatic Hydrocarbon
pH	Potential of Hydrogen
PDO	Persulfide dioxygenase
PPD	Personal Protection Device
PPE	Personal Protection Equipment
PTCC	Persian Type Culture Collection
PRESS	Predicted Residual Error Sum Square
R1/R2	Reaction Rate
RE	Removal Efficiency
RFD	Reference Dose
RFC	Reference Concentration
RpoS/H	RNA Polymerase sigma gene S/H
RSM	Response Surface Methodology
SEM	Scanning Electron Microscopy
S^{2-}	Sulfide ion
SOB	Sulfide Oxidizing Bacteria
SRB	Sulfate Reduction Bacteria
$S_2O_3^{-2}$	Thiosulfate
S^0	Elemental sulfur
SO_3^{2-}	Sulfite
SO_4^{2-}	Sulfate
SQR	Sulfite Quinine Reductase
SOX	Sulfide Oxidizing gene
SCR	Sulfide Cytochrome Reductase
SLR	Sludge Loading rate
STEL	Short-time Exposure Limit
TOMES	Thiosulfate-Oxidizing Multi-Enzyme System
TVL	Threshold Value Limit
TDS	Total Dissolved Solid
TSS	Total Suspended Solid

VFAs	Volatile Fatty Acids
VSLR	Volumetric Sulfide Loading Rate
VSS	Volatile Suspended Solid
V_{uP}	Upflow Velocity
UASB	Upflow Anaerobic Sludge Bed
WHO	World Health Organization
WQI	Water Quality Index
WWTPs	Waste Water Treatment Plants

REFERENCES

Abd.Aziz Bin Mohd Azoddein. (2013). *Mercury Removal From Petroleum Based Industries Wastewater by Pseudomonas putida (ATCC 49128) in Membrane Bioreactor*. A Ph.D. Thesis, University Malaysia Pahang (UMP).

Abd.Aziz Bin Mohd Azoddein, Mani Malam Ahmad, Rosli Mohd Yunus, S. N. M. N. (2016). A Bioremediation Approach to Mercury Removal in a Shake Flask Culture Using *Pseudomonas putida* (ATCC 49128). *Journal of Analytical & Bioanalytical Techniques*, *7*(3).

Ahmad, M.M., Azoddein A.M., Zahari M.A.K.M. Seman, M. N., and Jami. M. S. (2017). Biological Sulfide Oxidation and its Impact on Cell Biomass Synthesis by Mesophilic Bacterium. *Journal of Chemical Engineering and Industrial Biotechnology*, *1*(1), 83–96.

AI-Jawhari, I. F. H., Mhail, N. J., & AI-RuthaAli, S. A. (2015). The efficiency of *Pseudomonas aeruginosa* and *Escherichia coli* to the treatment of effluent petroleum wastewater from AI-Nasiriya refinery – Iraq. *International Journal of Basic and Applied Sciences*, *4*(4), 404.

Akbarzadeh, A., Khodabakhshi, A., & Arbabi, M. (2012). Optimization of the SBR system for enhanced biological phosphorus and nitrogen removal. *International Journal of Environmental Health Engineering*, *1*(1), 49.

Al Taweel, A. M., Shah, Q., & Aufderheide, B. (2012). Effect of mixing on microorganism growth in loop bioreactors. *International Journal of Chemical Engineering*, *2012*.

Alara, O. R., Abdul Mudalip, S. K., & Olalere, O. A. (2017). Optimization of mangiferin extracted from *Phaleria macrocarpa* fruits using response surface methodology. *Journal of Applied Research on Medicinal and Aromatic Plants*, *5*, 82–87.

Alcántara Sergio, Velasco Antonio, Muñoz Ana, Cid Juan, R. S., & Elías, R.-F. (2004). Hydrogen Sulfide Oxidation by a Microbial Consortium in a Recirculation Reactor System: Sulfur Formation under Oxygen Limitation and Removal of Phenols. *Environmental Science and Technology*, *38*(3), 918–923.

Alesia, F. D. (2014). *Optimization of Elemental Sulphur Recovery During Acid Mine*. A Masters Thesis, University of Pretoria.

Alfonsín, C., Lebrero, R., Estrada, J. M., Muñoz, R., Kraakman, N. J. R., Feijoo, G., & Moreira, M. A. T. (2015). Selection of odor removal technologies in wastewater treatment plants: A guideline based on Life Cycle Assessment. *Journal of Environmental Management*, *149*, 77–84.

Alonso, S. (2016). Novel Preservation Techniques for Microbial Cultures. In U. Springer (Ed.), *Novel Food Fermentation Technologies* (pp. 7–34). Switzerland: Springer Publishing International.

Altaş, L., & Büyükgüngör, H. (2008). Sulfide removal in petroleum refinery wastewater by chemical precipitation. *Journal of Hazardous Materials*, *153*(1–2), 462–469.

An, S., Tang, K., & Nemati, M. (2010). Simultaneous biodesulphurization and denitrification using an oil reservoir microbial culture: Effects of sulfide loading rate and sulfide to nitrate loading ratio. *Water Research*, *44*(5), 1531–1541.

Araujo, C. S. T., Carvalho, D. C., Rezende, H. C., Almeida, I. L. S., Coelho, L. M., Coelho, N. M. M., Marques, T. L., Alves, V. N. (2013). Bioremediation of waters contaminated with heavy metals using Moringa oleifera seeds as biosorbent. *Applied Bioremediation - Active and Passive Approaches*, (November 2015), 227–255.

Azizan, N. H., Apun, K. A., Bilungb, L. M., Vincent, M., Roslan, Hussaini, A., A. A. S. A. A. (2016). Crude Oil Bioremediation by Indigenous Bacteria Isolated from Oily Sludge. *Jurnal Teknologi*, *2*, 61–66.

Azoddein, A. A. M., Yunus, R. M., Sulaiman, N. M., Bustary, A. B., & Sabar, K. (2015). Mercury Removal Using *Pseudomonas putida* (ATTC 49128): Effect of Acclimatization Time, Speed and Temperature of Incubator Shaker. *International Journal of Biological, Biomolecular, Agricultural, Food and Biotechnological Engineering*, *9*(2), 204–209.

Azoddein, A. M., Azli, F. A. M., Bustary, A. B., Sulaiman, M. H., Salehen, A. Z. M., Seman, M. N. A., Nurdin, S., Sulaiman, M. (2016). Characterization of Enzyme Produced From *Pseudomonas Putida* for BTX (Benzene, Toluene & Xylene) Treatment in Petrochemical Industry Wastewater System. *International Journal of Research in Engineering and Science (IJRES)*, *4*(91), 16–20.

Azoddein, M. A. A., Ahmad, M. M., Yunus, R. M., Meriam, N., & Sulaiman, N. (2017). Effect of Acclimatization Time to Microbial Cell Growth and Biosynthesis of Mesophilic Gammaproteobacterium, in Orbital Shake Flasks. *MATEC Web of Conferences*, *04003*(109).

Azoddein, M. A. A., Yunus, R. M., Sulaiman, N. M., Bustary, A. B., Azli, F. A. (2015). Mercury Removal from Actual Petroleum Based Industries Wastewater by *P. putida* in Membrane Bioreactor. *International Journal of Scientific & Technology Research*, volume 4, issue 06, June 2015

Bae, W., Han, D., Cui, F., & Kim, M. (2014). Microbial evaluation for biodegradability of recalcitrant organic in textile wastewater using an immobilized-cell activated sludge process. *KSCE Journal of Civil Engineering*, *18*(4), 964–970.

Bandari, F., Safa, F., & Shariati, S. (2015). Application of Response Surface Method for Optimization of Adsorptive Removal of Eriochrome Black T Using Magnetic Multi-Wall Carbon Nanotube Nanocomposite. *Arabian Journal for Science and Engineering*, *40*(12), 3363–3372.

Banerjee, A., & Ghoshal, A. K. (2010). Isolation and characterization of hyper phenol tolerant *Bacillus sp*. from oil refinery and exploration sites. *Journal of Hazardous Materials*, *176*(1–3), 85–91.

Banerjee, A., & Ghoshal, A. K. (2016). Biodegradation of real petroleum wastewater by immobilized hyper phenol-tolerant strains of *Bacillus cereus* in a fluidized bed bioreactor. *3 Biotech*, *6*(2), 137.

Barbosa, V. L., & Stuetz, R. M. (2013). Performance of activated sludge diffusion for biological treatment of hydrogen sulfide gas emissions. *Water Science and Technology*, *68*(9), 1932–1939.

Benyahia, F., Abdulkarim, M., Embaby, A., & Rao, M. (2006). Refinery Wastewater Treatment- A true Technological Challenge. *The Seventh Annual U.A.E. University Research Conference*, 186–193.

Beristain-Cardoso, R., Texier, A. C., Sierra-Álvarez, R., Razo-Flores, E., Field, J. A., & Gómez, J. (2009). Effect of initial sulfide concentration on sulfide and phenol oxidation under denitrifying conditions. *Chemosphere*, *74*(2), 200–205.

Betancur, M. J., Martínez, F., Ocampo, C., Moreno, J. A., Buitrón, G., & Moreno-Andrade, I. (2009). Acclimatization model of aerobic bioreactor for the treatment of toxic wastewater. *Simulation Modelling Practice and Theory*, *17*(4), 680–691.

Bob, M. M., Azmi, S. I., Halim, M. H. A., Jamal, N. S., Nor-, A., & Ujang, Z. (2015). Sequencing Batch Reactors Operation at High Temperature for Synthetic Wastewater Treatment Using Aerobic Granular Sludge. *International Water Technology Journal*, *5*(1), 69–76.

Borah, D., & Yadav, R. N. S. (2014). Biodegradation of petroleum oil by a novel *Bacillus cereus* strain DRDU1 from an automobile engine. *International Journal of Environmental Research*, *8*(4), 1287–1294.

Boumnijel, I., Ben Amor, H., Chekir, H., & Hajji, N. (2016). Hydrogen sulfide removal from the effluents of a phosphoric acid production unit by absorption into chlorinated seawater under alkaline conditions. *Comptes Rendus Chimie*, *19*(4), 517–524.

Brian, O. (2014). *Sulfate, Hydrogen Sulfide, Sulfate-Reducing Bacteria - How to Identify and Manage*. *Water Research Watershed Center*. https://www.water-research.net/index.php/sulfates.

Brian, O. (2016). *Total Dissolved Solids and Water Quality*. *Water Research Center*. http://www.water-research.net/index.php/water-treatment/tools/total-dissolved-solids

Buisman, C. J. N., Geraats, B. G., Ijspeert, P., & Lettinga, G. (1990). Optimization of Sulfur Production in a Biotechnological Sulfide-Removing Reactor. *Biotechnology and Bioengineering*, *35*(1), 50–56.

Buisman, C. J. N., Jspeert, P. I., Hof, A., Janssen, A. J. H., Hagen, R. Ten, & Lettinga, G. (1991). Kinetic parameters of a mixed culture oxidizing sulfide and sulfur with oxygen. *Biotechnology and Bioengineering*, *38*(8), 813–820.

Bujang, M., & Ibrahim, Noor Azlina, A. a/l E. R. (2013). Biodegradation of oily wastewater by a pure culture of *Bacillus cereus*. *ARPN Journal of Agricultural and Biological Science*, *8*(2), 108–115.

Burbano-Figueroa, O. Jaramillo, M., Moreno-Moran M. and Fernández-Izquierdo, P. (2015). Effect of Sulfate Loading Rate and Organic Loading Rate on Anaerobic Baffled Reactors Used for Treatment of Sanitary Landfill Leachates. *Brazilian Journal of Chemical Engineering*, *32*(02), 385–395.

Cai, J., Zheng, P., Qaisar, M., & Zhang, J. (2017). Elemental sulfur recovery of biological sulfide removal process from wastewater: A review. *Critical Reviews in Environmental Science and Technology*, *0*(0), 1–21.

Camiloti, P. R., Oliveira, G. H. D., & Zaiat, M. (2016). Sulfur Recovery from Wastewater Using a Micro-aerobic External Silicone Membrane Reactor (ESMR). *Water, Air, and Soil Pollution*, *227*(1), 1–10.

Caroline, C., Philippe, S., Soumille, H., Nguyen-the, C., & Schmitt, P. (2000). Effect of temperature on growth characteristics of *Bacillus cereus* TZ415, (August 2016), 1–6.

Cerqueira, V. S., Hollenbach, E. B., Maboni, F., Camargo, F. A. O., Peralba, M. do C. R., & Bento, F. M. (2012). Bioprospection and selection of bacteria isolated from environments contaminated with petrochemical residues for application in bioremediation. *World Journal of Microbiology and Biotechnology*, *28*(3), 1203–1222.

Chaiprapat, S., Mardthing, R., Kantachote, D., & Karnchanawong, S. (2011). Removal of hydrogen sulfide by complete aerobic oxidation in acidic biofiltration. *Process Biochemistry*, *46*(1), 344–352.

Chan, Y., Chong, M., & Law, C. (2013). Optimization of palm oil mill effluent treatment in an integrated anaerobic-aerobic bioreactor. *Sustain. Environ. Res.*, *23*(3), 153–170.

Chen, C., Liu, L., Lee, D. J., Guo, W., Wang, A., Xu, X., Zhou, X., Wu, D., Ren, N. (2014). Integrated simultaneous desulfurization and denitrification (ISDD) process at various COD/sulfate ratios. *Bioresource Technology*, *155*, 161–169.

Chen, C., Wang, A., Ren, N., Zhao, Q., Liu, L., Adav, S. S., Lee, D., Chang, J. S. (2010). Enhancing denitrifying sulfide removal with functional strains under micro-aerobic condition. *Process Biochemistry*, *45*(6), 1007–1010.

Chen, F., Yuan, Y., Chen, C., Zhao, Y., Tan, W., Huang, C., Xu, X., Wang, A. (2016). Investigation of colloidal biogenic sulfur flocculation: Optimization using response surface analysis. *Journal of Environmental Sciences (China)*, *42*, 227–235.

Chen, Y., Cheng, J. J., & Creamer, K. S. (2008). Inhibition of anaerobic digestion process: A review. *Bioresource Technology*, *99*(10), 4044–4064.

Chen, Y., Zhang, J. G., Sun, H. J., & Wei, Z. J. (2014). Pectin from *Abelmoschus esculentus*: Optimization of extraction and rheological properties. *International Journal of Biological Macromolecules*, *70*, 498–505.

Chunshuang, L., Kang, H., Dongfeng, Z., Yadonag, G., & Lihong, L. (2016). Enhanced Performance of Denitrifying Sulfide Removal Process by 1, 2-Naphthoquinone-4-Sulphonate. *Process Research*, *18*(1), 22–28.

Dahl, C., & Friedrich, C. G. (2008). *Microbial Sulfur Metabolism*. (C. D. C. G. Friedrich, Ed.). Springer-Verlag.

Darsa, K. V., Thatheyus, A. J., & Ramya, D. (2014). Biodegradation of petroleum compound using the bacterium *Bacillus Subtilis*. *Science International*, *2*(1), 20–25.

Das, N., & Chandran, P. (2011). Microbial degradation of petroleum hydrocarbon contaminants: an overview. *Biotechnology Research International*, *2011*, 941810.

Datusahlan, M., Ishak, W. M. F. W., & Makky, E. a. (2013). Biodegradation of Wastewater Oil Pollutants, Identification and Characterization: A Case Study – Galing River, Kuantan Pahang, Malaysia. *International Journal of Bioscience, Biochemistry, and Bioinformatics*, *3*(6), 579–582.

Daud, Wan Mohd Ashri Wan Hasan, D. B., & A. R. Abdul Aziz, A. (2011). Application of response surface methodology in process parameters optimization for phenol mineralization using Fenton's peroxidation. *African Journal of Biotechnology*, *10*(50), 10218–10231.

de Lucena, D. K., Puhler, A., & Weidner, S. (2010). The role of sigma factor RpoH1 in the pH stress response of *Sinorhizobium meliloti*. *BMC Microbiol*, *10*(1), 265.

Dhandayuthapami, S.K.(2013).Optimization of Phenol Biodegradation By *Pseudomonas putida*. *International Journal of Pharma and Bio Sciences*, *4*(3), 405–413.

Di Capua, F., Ahoranta, S. H., Papirio, S., Lens, P. N. L., & Esposito, G. (2016). Impacts of sulfur source and temperature on sulfur-driven denitrification by pure and mixed cultures of *Thiobacillus*. *Process Biochemistry*, *51*(10), 1576–1584.

Diaz, I. Perez, S. I. Ferrero, E. M. Fdz-Polanco, M. (2011). Effect of oxygen dosing point and mixing on the microaerobic removal of hydrogen sulfide in sludge digesters. *Bioresource Technology*, *102*(4), 3768–3775.

Divya, M., Aanand, S., Srinivasan, A., & Ahilan, B. (2015). Bioremediation – An eco-friendly tool for effluent treatment: A Review. *International Journal of Appl Ied Research*, *1*(12), 530–537.

Diya'uddeen, B. H., Daud, W. M. A. W., & Abdul Aziz, A. R. (2011). Treatment technologies for petroleum refinery effluents: A review. *Process Safety and Environmental Protection*, *89*(2), 95–105.

DOE. (2010). *Environmental Requirements: A Guide For Investors*. *Department of Environment* (Eleventh Ed.). Putrajaya. Malaysia.

Dorn, J. G., Frye, R. J., & Maier, R. M. (2003). Effect of Temperature, pH, and Initial Cell Number on luxCDABE and nah Gene Expression during Naphthalene and Salicylate Catabolism in the Bioreporter Organism *Pseudomonas putida* RB1353. *Applied and Environmental Microbiology*, *69*(4), 2209–2216.

Edwards, S., Alharthi, R. and Ghaly, A. E. (2011). Removal of Hydrogen Sulfide from Water. *American Journal of Environmental Sciences*, *7*(4), 295–305.

El-Naas, M. H., Acio, J. A., & El Telib, A. E. (2014). Aerobic biodegradation of BTEX: Progress and Prospects. *Journal of Environmental Chemical Engineering*, *2*(2), 1104–1122.

El-Naas, M. H., Alhaija, M. A., & Al-Zuhair, S. (2014). Evaluation of a three-step process for the treatment of petroleum refinery wastewater. *Journal of Environmental Chemical Engineering*, *2*(1), 56–62.

Enning, D., & Garrelfs, J. (2014). Corrosion of iron by sulfate-reducing bacteria: New views of an old problem. *Applied and Environmental Microbiology*, *80*(4), 1226–1236.

Environmental Quality Acts. (Acts, 127) 1979 (Amended, 2011). *Malaysian Environmental Quality (Sewage and Industrial Effluents) Regulations*.

Esakkiraj, P., Meleppat, B., Lakra, A. K., Ayyanna, R., & Arul, V. (2016). Cloning, expression, characterization, and application of protease produced by *Bacillus cereus* PMW8. *RSC Adv.*, *6*(45), 38611–38616.

Escobar, S., Rodriguez, A., Gomez, E., Alcon, A., Santos, V. E., & Garcia-Ochoa, F. (2016). Influence of oxygen transfer on *Pseudomonas putida* effects on growth rate and biodesulfurization capacity. *Bioprocess and Biosystems Engineering*, *39*(4), 545–554.

Esmaeili Faraj, S. H., Esfahany, M. N., Jafari-Asl, M., & Etesami, N. (2014). Hydrogen sulfide bubble absorption enhancement in water-based nanofluids. *Industrial and Engineering Chemistry Research*, *53*(43), 16851–16858.

Estrada, J. M., Kraakman, N. J. R. B., Munnoz, R., & Lebrero, R. (2011). A Comparative Analysis of Odour Treatment Technologies in Wastewater Treatment Plants. *Environmental Science & Technology*, *45*(3), 1100–1106.

Estrada, J. M., Kraakman, N. J. R., Lebrero, R., & Muñoz, R. (2015). Integral approaches to wastewater treatment plant upgrading for odor prevention: Activated Sludge and Oxidized Ammonium Recycling. *Bioresource Technology*, *196*, 685–693.

Fonseca, P., Moreno, R., & Rojo, F. (2011). The growth of *Pseudomonas putida* at low temperature: Global transcriptomic and proteomic analyses. *Environmental Microbiology Reports*, *3*(3), 329–339.

François, F., Lombard, C., Guigner, J. M., Soreau, P., Brian-Jaisson, F., Martino, G., Manon, G., Molinier, D., Pignol, A. L., Peduzzi, J., Severine, Z., Rebuffat, S. (2012). Isolation and characterization of environmental bacteria capable of extracellular biosorption of mercury. *Applied and Environmental Microbiology*, *78*(4), 1097–1106.

Franklin, O., Hall, E. K., Kaiser, C., Battin, T. J., Franklin, O., Hall, E. K., Kaiser, C., Battin, T. J., Richter, A. (2011). Optimization of Biomass Composition Explains Microbial Growth-Stoichiometry Relationships. *The American Naturalist*, *177*(2), 29–42.

Fu, G., Huang, S., Ye, Y., Wu, Y., Cen, Z., & Lin, S. (2010). Characterization of a bacterial biocontrol strain B106 and its efficacies on controlling banana leaf spot and post-harvest anthracnose diseases. *Biological Control*, *55*(1), 1–10.

Galaction, A., Blaga, A. C., Ciobanu, C. P., Turnea, M., & Ca, D. (2015). Distribution of Oxygen Transfer Rates in Stirred Bioreactor for Different Fermentation Broths - Oxygen-Vector Dispersions. *Environmental Engineering and Management Journal*, *14*(2), 433–447.

Garcia, S. L. (2016). Mixed cultures as model communities: Hunting for ubiquitous microorganisms, their partners, and interactions. *Aquatic Microbial Ecology*, *77*(2), 79–85.

Garg, S. K., Tripathi, M., & Lal, N. (2015). Statistical Design for Optimization of Process Parameters for Biodecolorization of Reactive Orange 4 Azo Dye by *Bacillus cereus* Isolate. *Research Journal of Microbiology*, *10*(11), 4935.

Ge, H., Zhang, L., Batstone, D. J., Keller, J., & Yuan, Z. (2013). Impact of Iron Salt Dosage to Sewers on Downstream Anaerobic Sludge Digesters: Sulfide Control and Methane Production. *Journal of Environmental Engineering*, *139*(4), 594–601.

Gerard Muyzer, J. Gijs Kuenen, L. A. R. (2013). Colorless Sulfur Bacteria. In *The Prokaryotes: Prokaryotic Physiology and Biochemistry* (pp. 1–662).

Ghosh Ray, S., & Ghangrekar, M. M. (2015). Enhancing organic matter removal, biopolymer recovery, and electricity generation from distillery wastewater by combining fungal fermentation and microbial fuel cell. *Bioresource Technology*, *176*, 8–14.

Ghosh, W., & Dam, B. (2009). Biochemistry and molecular biology of lithotrophic sulfur oxidation by taxonomically and ecologically diverse bacteria and archaea. *FEMS Microbiology Reviews*, *33*(6), 999–1043.

Granato, D., & de Araújo Calado, V. M. (2013). The use and importance of the design of experiments (DOE) in process modeling in food science and technology. In *Mathematical and Statistical Methods in Food Science and Technology* (pp. 1–18).

Habeeb, O.A., Ramesh, K., Gomaa Ali, A.M., Yunsu, R.M., Thanusha, T. K. and Olarere, O. A. (2016). Modeling and Optimization for H 2 S Adsorption from Wastewater Using Coconut Shell Based Activated Carbon. *Australian Journal of Basic and Applied Sciences*, *10*(17), 136–147.

Hall, B. G., Acar, H., Nandipati, A., & Barlow, M. (2014). Growth rates made easy — m*olecular Biology and Evolution*, *31*(1), 232–238.

Hamid Rashedi, Ali Izadi, M. E. B. (2015). Optimization of Operational Parameters in Rhamnolipid Production by *Pseudomonas aeruginosa* MM1011 in a Miniaturized Shaken Bioreactor. *Journal of Applied Biotechnology Reports*, *2*(3), 271–278.

Hao, T., Xiang, P., Mackey, H. R., Chi, K., Lu, H., Chui, H., Loosdrecht, M.C.M. van, Chen, G.-H. (2014). A review of biological sulfate conversions in wastewater treatment. *Water Research*, *65*, 1–21.

Hariz, I. Ben, Ayni, F. Al, & Monser, L. (2014). Removal of sulfur compounds from petroleum refinery wastewater through adsorption on modified activated carbon. *Water Science and Technology*, *70*(8), 1376–1382.

Harwood, C. S., Fosnaugh, K., & Dispensa, M. (1989). Flagellation of Pseudomonas putida and analysis of its motile behavior. *Journal of Bacteriology*, *171*(7), 4063–4066.

Henri, G., Gilles, B., & Fernando, M. (2011). Microbial technologies for Hydrogen Sulphide removal from gas streams.

Heo, S.-K., Lee, J.-Y., Baek, S.-B., & Ha, S.-D. (2009). A response surface model to describe the effect of temperature and pH on the growth of *Bacillus cereus* in cooked rice. *Journal of Food Protection*, *72*(6), 1296–1300.

Hodaifa, G., Martinez, M. E., Orpez, R., & Sánchez, S. (2010). Influence of hydrodynamic stress in the growth of *Scenedesmus obliquus* using a culture medium based on olive-mill wastewater. *Chemical Engineering and Processing: Process Intensification*, *49*(11), 1161–1168.

Hooshyar Hossini, Abbas Rezaee, S. R. (2014). Statistical screening of hexavalent chromium biosorption by Sargassum. *Iranian Journal of Health, Safety, and Environment*, *1*(1), 36–42.

Hunter, R. D., Ekunwe, S. I. N., Dodor, D. E., Hwang, H. M., & Ekunwe, L. (2005). *Bacillus subtilis* is a potential degrader of pyrene and benzo[a]pyrene — *International Journal of Environmental Research and Public Health*, *2*(2), 267–271.

IPIECA Operations Best Practice. (2010). *Petroleum refining water/wastewater*. *Report: The global oil and gas industry association for environmental and social issues*.

Ishak, S., Malakahmad, A., & Isa, M. H. (2012). Refinery wastewater biological treatment : A short review. *Journal of Scientific & Industrial Research*, *71*, 251–256.

Jamaly, S., Giwa, A., & Hasan, S. W. (2015). Recent improvements in oily wastewater treatment : Progress, challenges, and future opportunities. *Journal of Environmental Sciences*, *37*, 15–30.

Janssen, A. J. H. (1996). *Formation and colloidal behavior of elemental sulfur produced from the biological oxidation of hydrogen sulfide*. A Ph.D. Thesis.

Janssen, A. J. H., Sleyster, R., Van der Kaa, C., Jochemsen, A., Bontsema, J., & Lettinga, G. (1995). Biological sulfide oxidation in a fed-batch reactor. *Biotechnology and Bioengineering*, *47*(3), 327–333.

Jena, V., Dixit, S., & Gupta, S. (2013). Assessment of water quality index of industrial area surface water samples. *International Journal of ChemTech Research*, *5*(1), 278–283.

Jensen, H., Biggs, C. A., & Karunakaran, E. (2016). The importance of sewer biofilms. *Wiley Interdisciplinary Reviews: Water*, *3*(4), 487–494.

Jiang, G., Gutierrez, O., Sharma, K. R., Keller, J., & Yuan, Z. (2011). Optimization of intermittent, simultaneous dosage of nitrite and hydrochloric acid to control sulfide and methane productions in sewers. *Water Research*, *45*(18), 6163–6172.

Jing, C., Ping, Z., & Mahmood, Q. (2010). Influence of various nitrogenous electron acceptors on the anaerobic sulfide oxidation. *Bioresource Technology*, *101*(9), 2931–2937.

Jukic, A. (2011). *Petroleum Refining : Introduction, Products Refinery's Configuration, Hydrogen Technologies*.

Jungles, M. K., Campos, J. L., & Costa, R. H. R. (2014). Sequencing batch reactor operation for treating wastewater with aerobic granular sludge. *Brazilian Journal of Chemical Engineering*, *31*(1), 27–33.

Kafle, G. K., Chen, L., Neibling, H., & Brian He, B. (2014). Field evaluation of wood bark-based down-flow biofilters for mitigation of odor, ammonia, and hydrogen sulfide emissions from confined swine nursery barns. *Journal of Environmental Management*, *147*, 164–174.

Kalantari, H., Nosrati, M., Shojaosadati, S. A., & Shavandi, M. (2017). Optimization of Factors Affecting on Sulfide Oxidation from Synthetic Spent Caustic by Haloalkaliphilic *Thioalkalivibrio versutus* : Application of Response Surface Methodology. *Iranian Journal of Chemical Engineering*, *14*(1).

Kamika, I. and, & Momba, M. N. B. (2012). Comparing the tolerance limits of selected bacterial and protozoan species to vanadium in wastewater systems. *Water, Air, and Soil Pollution*, *223*(5), 2525–2539.

Kappler, U., Bennett, B., Deutzmann, R., Mcewan, A. G., & Dahl, C. (2000). Sulfite : Cytochrome c Oxidoreductase from *Thiobacillus novellus*. *The Journal of Biological Chemistry*, *275*(18), 13202–13212.

Kappler, U., & Dahl, C. (2001). Enzymology and molecular biology of prokaryotic cell oxidation 1. *FEMS Microbiology Letters*, *203*(1), 1–9.

Kazmierczak-Razna, J., Gralak-Podemska, B., Nowicki, P., & Pietrzak, R. (2015). The use of microwave radiation for obtaining activated carbons from sawdust and their potential application in removal of NO_2 and H_2S. *Chemical Engineering Journal*, *269*, 352–358.

Khan, N., Yahaya, E. M., Faizal, M., Mohamed, P., & Abustan, I. (2010). Process Optimization for Zn (II) Removal by Activated Carbon Prepared from Rice Husk using Chemical Activation. *International Journal of Basic & Applied Sciences IJBAS-IJENS*, *10*(6), 79–83.

Khodaei, K., Nassery, H. R., Asadi, M. M., Mohammadzadeh, H., & Mahmoodlu, M. G. (2017). BTEX biodegradation in contaminated groundwater using a novel strain (*Pseudomonas sp*. BTEX-30). *International Biodeterioration & Biodegradation*, *116*, 234–242.

Kieu, T. Q. H., Nguyen, T. Y., Dang, T. Y., Nguyen, T. B., Vuong, T. N., & Horn, H. (2015). Optimization of sulfide production by an indigenous consortium of sulfate-reducing bacteria for the treatment of lead-contaminated wastewater. *Bioprocess and Biosystems Engineering*, *38*(10), 2003–2011.

Kim, B., & Kim, J. (2013). Optimization of culture conditions for the production of biosurfactant by *Bacillus subtilis* JK-1 using response surface methodology. *Journal of the Korean Society for Applied Biological Chemistry*, *56*(3), 279–287.

Kim, J. H., Rene, E. R., & Park, H. S. (2008). Biological oxidation of hydrogen sulfide under steady and transient state conditions in an immobilized cell biofilter. *Bioresource Technology*, *99*(3), 583–588.

Kimura, T., & Ito, Y. (2001). Two bacterial mixed culture systems suitable for degrading terephthalate in wastewater. *Journal of Bioscience and Bioengineering*, *91*(4), 416–418.

Klatt, J. M., & Polerecky, L. (2015). Assessment of the stoichiometry and efficiency of CO2 fixation coupled to reduced sulfur oxidation. *Frontiers in Microbiology*, *6*(MAY).

Klok, J. B. M., Van Den Bosch, P. L. F., Buisman, C. J. N., Stams, A. J. M., Keesman, K. J., & Janssen, A. J. H. (2012). Pathways of sulfide oxidation by haloalkaliphilic bacteria in limited-oxygen gas lift bioreactors. *Environmental Science and Technology*, *46*(14), 7581–7586.

Kousi, P., Remoundaki, E., Hatzikioseyian, A., & Tsezos, M. (2015). Sulfate-reducing bioreactors : current practices and perspectives. In *IWA Balkan Young Water Professional, 2015, May 10-12, 2015* (pp. 409–417). Thessaloniki.

Kranzler, M., Stollewerk, K., Rouzeau-Szynalski, K., Blayo, L., Sulyok, M., & Ehling-Schulz, M. (2016). Temperature exerts control of *Bacillus cereus* emetic toxin production on post-transcriptional levels — f*rontiers in Microbiology*, *7*(Oct.), 1–10.

Krayzelova, L., Bartacek, J., Díaz, I., Jeison, D., Volcke, E. I. P., & Jenicek, P. (2015). Microaeration for hydrogen sulfide removal during anaerobic treatment: a review. *Reviews in Environmental Science and Biotechnology*, *14*(4), 703–725.

Krayzelova, L., Bartacek, J., Kolesarova, N., & Jenicek, P. (2014). Microaeration for hydrogen sulfide removal in UASB reactor. *Bioresource Technology*, *172*, 297–302.

Krzysztof Barbusinki and Katarzyna Kalemba. (2016). Use of biological methods for removal of H_2S from biogas in wastewater treatment plant-A review. *Architecture Civil Engineering Environment*, *1*, 103–112.

Lafita, C., Penya-Roja, J. M., Sempere, F., Waalkens, A., & Gabaldón, C. (2012). Hydrogen sulfide and odor removal by field-scale biotrickling filters: Influence of seasonal variations of load and temperature. *Journal of Environmental Science and Health - Part A Toxic/Hazardous Substances and Environmental Engineering*, *47*(7), 970–978.

Lakshmi B.K.M and Hemalatha K.P.J. (2015). Response surface optimization of medium composition for alkaline protease production by *Bacillus cereus* strain S8. *International Journal of Pure and Applied Bioscience*, *3*(4), 216–223.

Lambert, T. W., Goodwin, V. M., Stefani, D., & Strosher, L. (2006). Hydrogen sulfide (H_2S) and sour gas effects on the eye. A historical perspective. *The Science of the Total Environment*, *367*(1), 1–22.

Lee, D. J., Chang, J. S., & Lai, J. Y. (2015). Microalgae-microbial fuel cell: A mini review. *Bioresource Technology*, *198*, 891–895.

Lee, D. J., Lee, C. Y., Chang, J. S., Liao, Q., & Su, A. (2015). Treatment of sulfate/sulfide-containing wastewaters using a microbial fuel cell: Single and two-anode systems. *International Journal of Green Energy*, *12*(10), 998–1004.

Lestari, R. A. S., Sediawan, W. B., Syamsiah, S., Sarto, & Teixeira, J. A. (2016). Hydrogen sulfide removal from biogas using salak fruit seeds packed bed reactor with sulfur-oxidizing bacteria as a biofilm. *Journal of Environmental Chemical Engineering*, *4*(2), 2370–2377.

Li, Q., Wang, M., Feng, J., Zhang, W., Wang, Y., Gu, Y., Song, C., Wang, S. (2013). Treatment of high-salinity chemical wastewater by indigenous bacteria-bioaugmented contact oxidation. *Bioresource Technology*, *144*, 380–386.

Li, W., Zhao, Q. Liang, & Liu, H. (2009). Sulfide removal by the simultaneous autotrophic and heterotrophic desulfurization-denitrification process. *Journal of Hazardous Materials*, *162*(2–3), 848–853.

Lin, W. C., Chen, Y. P., & Tseng, C. P. (2013). Pilot-scale chemical-biological system for efficient H_2S removal from biogas. *Bioresource Technology*, *135*, 283–291.

Liu, S., Ma, Q., Wang, B., Wang, J., & Zhang, Y. (2014). Advanced treatment of refractory organic pollutants in petrochemical industrial wastewater by bioactive enhanced ponds and wetland system. *Ecotoxicology*, *23*(4), 689–698.

Liu, W., Liang, C., Chen, J., & Zhu, L. (2013). Effect of operating parameters on sulfide biotransformation to sulfur. *Journal of Environmental Sciences (China)*, *25*(12), 2417–2421.

Lohwacharin, J., & Annachhatre, A. P. (2010). Biological sulfide oxidation in an airlift bioreactor. *Bioresource Technology*, *101*(7), 2114–2120.

Lorna Guerrero, Silvio Montalvo Cesar Huilinir, Jose Luis Campos, Andrea Barahona, R. B. (2016). Advances in the biological removal of sulfides from the aqueous phase in anaerobic processes : A review. *Environmental Reviews*, *24*(1), 84–100.

Maier, R. M. (2010). Bacterial Growth. In: *Environmental Microbiology*, (2nd ed), Academic Press (Elsevier), London, Pp 37–54.

Manconi, I. Carucci, A., Lens, P. (2007). Combined Removal of Sulfur Compounds and Nitrate by Autotrophic Denitrification in Bioaugmented Activated Sludge System. *Biotechnology and Bioengineering*, *98*(3), 551–560.

Mani, M. A., Abd.Aziz, M. A., Mior Ahmad K.M.Z., Mazrul, N.S., Faten, A. M. A. (2016). Assessment of sulfide concentration effects in a micro- oxygenated condition on the growth and removal. *Journal of Advanced Research in Materials Science*, *1*(1), 1–10.

Manikandaraja, P., & Senthilkumaran, R. (2014). A Study on degradation and characterization of heavy metals in industrial effluents waste using *Pseudomonas sp* isolated from soil samples, *1*(1), 63–72.

Manual, A. A. Q. (2013). Total Suspended Solids Dried. *Standard Methods for the Examination of Water and Wastewater, APHA-AWWA-WPCF* (21st Edition).

Masau, R. J. Y., Oh, J. K., & Suzuki, I. (2001). Mechanism of oxidation of inorganic sulfur compounds by thiosulfate-grown *Thiobacillus thiooxidans*. *Canadian Journal of Microbiology*, *47*(4), 348–358.

Mathioudakis, V. L., & Aivasidis, A. (2009). Effect of temperature on anoxic sulfide oxidation and denitrification in the bulk wastewater phase of sewer networks. *Water Science and Technology*, *59*(4), 705–712.

Mazzeo, D. E. C., Levy, C. E., de Angelis, D. de F., & Marin-Morales, M. A. (2010). BTEX biodegradation by bacteria from effluents of a petroleum refinery. *The science of the Total Environment*, *408*(20), 4334–4340.

McDonald, H. B. (2009). *Effect of sulfide inhibition and organic shock loading on anaerobic biofilm reactors treating low-temperature, high-sulfate wastewater. Ph.D. Thesis*.

Midha, V., Jha, M. K., & Dey, A. (2013). Neural network prediction of fluidized bed bioreactor performance for sulfide oxidation. *Korean Journal of Chemical Engineering*, *30*(2), 385–391.

Min, H. S., & Kim, H. S. (2010). Application of microbial fuel cell for the monitoring and control of sulfur-related odor generation. *Proceedings of International Conference on Biology, Environment and Chemistry* Vol.1, 102–104.

Mirzoyan, N., & Schreier, H. J. (2014). Effect of sulfide on the growth of marine bacteria. *Archives of Microbiology*, *196*, 279–287.

Moghanloo, G. M. M., Fatehifar, E., Saedy, S., Aghaeifa, Z., & Abbasnezhad, H. (2010). Biological oxidation of hydrogen sulfide in mineral media using a biofilm airlift suspension reactor. *Bioresource Technology*, *101*(21), 8330–8335.

Mohammad, Y. S., Igboro, S. B., Giwa, A., & Okuofu, C. A. (2014). Modeling and Optimization for Production of Rice Husk Activated Carbon and Adsorption of Phenol. *Hindawi Publishing Corporation Journal of Engineering*, *Volume 201*, 1–10.

Mohanty, S. S. (2012). *Microbial Degradation of Phenol : A Comparative Study. An M.Sc. Thesis,* National Institute of Technology, Rourkela. India.

Momen, S. B., Siadat, S. D., Akbari, N., Ranjbar, B., & Khajeh, K. (2016). Applying central composite design and response surface methodology to optimize growth and biomass production of *Haemophilus influenzae* type b. *Jundishapur Journal of Microbiology*, *9*(6).

Montebello, A. M., Fernández, M., Almenglo, F., Ramírez, M., Cantero, D., Baeza, M., & Gabriel, D. (2012). Simultaneous methyl mercaptan and hydrogen sulfide removal in the desulfurization of biogas in aerobic and anoxic biotrickling filters. *Chemical Engineering Journal*, *200–202*, 237–246.

Mora Mabel, Fernández Maikel, Gómez José Manuel, C. D., Lafuente Javier, G. X., & David, G. (2014). Kinetic and stoichiometric characterization of anoxic sulfide oxidation by SO-NR mixed cultures from anoxic biotrickling filters. *Applied Microbiology and Biotechnology*, *99*(1), 77–87.

Moraes, B. S., Orrú, J. G. T., & Foresti, E. (2013). Nitrogen and sulfide removal from the effluent of UASB reactor in a sequencing fed-batch biofilm reactor under intermittent aeration. *Journal of Biotechnology*, *164*(3), 378–385.

Moraes, B. S., Souza, T. S. O., & Foresti, E. (2012). Effect of sulfide concentration on autotrophic denitrification from nitrate and nitrite in vertical fixed-bed reactors. *Process Biochemistry*, *47*(9), 1395–1401.

Mosquera, S., González-Jaramillo, L. M., Orduz, S., & Villegas-Escobar, V. (2014). Multiple response optimization of *Bacillus subtilis* EA-CB0015 culture and identification of antifungal metabolites — *Biocatalysis and Agricultural Biotechnology*, *3*(4), 378–385.

Moura, M. C., Pontual, E. V, Paiva, P. M. G., & Coelho, L. C. B. B. (2013). An Outline to Corrosive Bacteria. *Microbial Pathogens and Strategies for Combating Them: Science, Technology and Education*, 11–22.

Mrozik, A., & Piotrowska-Seget, Z. (2010). Bioaugmentation as a strategy for cleaning up of soils contaminated with aromatic compounds. *Microbiological Research*, *165*(5), 363–375.

Mudliar, S., Giri, B., Padoley, K., Satpute, D., Dixit, R., Bhatt, P., Pandey, R., Juwarkar, A., Vaidya, A. (2010). Bioreactors for treatment of VOCs and odors - A review. *Journal of Environmental Management*, *91*(5), 1039–1054.

Mukherjee, A. K., & Bordoloi, N. K. (2012). Biodegradation of benzene, toluene, and xylene (BTX) in liquid culture and soil by *Bacillus subtilis* and *Pseudomonas aeruginosa* strains and a formulated bacterial consortium. *Environmental Science and Pollution Research*, *19*(8), 3380–3388.

Munna, M. S., Zeba, Z., and Noor, R. (2015). Influence of temperature on the growth of Drosophila melanogaster. *Stamford Journal of Microbiology*, *5*(1), 9–12.

Munna, M. S., Tamanna, S., Afrin, M. R., Sharif, G. A., Mazumder, C., Kana, K. S., Urmi, N. J., Uddin, M. A., Rahman, T., Noor, R. (2014). Influence of Aeration Speed on Bacterial Colony Forming Unit (CFU) Formation Capacity. *American Journal of Microbiological Research, 2*(1), 47–51.

Murtey, M. D. and, & Ramasamy, P. (2016). Sample Preparations for Scanning Electron Microscopy – Life Sciences. In M. J. and R. Kral. (Ed.), *Modern Electron Microscopy in Physical and Life Sciences* (pp. 161–185). INTECH Open.

Norhidayah M., Shaabanb, A., Dimin, M.F., Norazlina, M.Y., Rostam, O. (2015). Optimization of Biodegradable Urea Production Process to Minimize Ammonia Release Through Response Surface Method Experimental Design. *Journal of Advanced Research in Applied Science and Engineering Technology*, *2*(1), 9–18.

Nwabueze, T. U. (2010). Basic steps in adapting response surface methodology as mathematical modeling for bioprocess optimization in the food systems. *International Journal of Food Science and Technology*, *45*(9), 1768–1776.

Olfa Tabbene, Imen Ben Slimane, Kais Djebali, Maria-Luisa Mangoni, M.-C. U. and F. L. (2009). Optimization of medium composition for the production of antimicrobial activity by *Bacillus subtilis* B38. *Biotechnology Progress*, *25*(5), 1267–1274.

Olmos, E., Mehmood, N., Haj Husein, L., Goergen, J. L., Fick, M., & Delaunay, S. (2013). Effects of bioreactor hydrodynamics on the physiology of Streptomyces. *Bioprocess and Biosystems Engineering*, *36*(3), 259–272.

Omri, I., Aouidi, F., Bouallagui, H., Godon, J. J., & Hamdi, M. (2013). Performance study of biofilter developed to treat H_2S from wastewater odor. *Saudi Journal of Biological Sciences*, *20*(2), 169–176.

Onsekizoglu, P., Bahceci, K. S., & Acar, J. (2010). The use of factorial design for modeling membrane distillation. *Journal of Membrane Science*, *349*, 225–230.

Osin, O. A., Yu, T., & Lin, S. (2017). Oil refinery wastewater treatment in the Niger Delta, Nigeria: current practices, challenges, and recommendations. *Environmental Science and Pollution Research*, *24*(28), 22730–22740.

Ozekmekci, M., Salkic, G., & Fellah, M. F. (2015). Use of zeolites for the removal of H_2S: A mini-review. *Fuel Processing Technology*, *139*, 49–60.

Pang, B. W., Jiang, C. H., Yeung, M., Ouyang, Y., & Xu, J. (2017). Removal of dissolved sulfides in aqueous solution by activated sludge: mechanism and characteristics. *Journal of Hazardous Materials*, *324*, 732–738.

Park, C. W., Yoon, K. Y., Byeon, J. H., Kim, K., & Hwang, J. (2012). Development of rapid assessment method to determine bacterial viability based on ultraviolet and visible (UV-Vis) spectroscopy analysis including application to bioaerosols. *Aerosol and Air Quality Research*, *12*(3), 395–404.

Park, K., Lee, H., Phelan, S., Liyanaarachchi, S., Marleni, N., Navaratna, D., Jegatheesan, V., Shu, L. (2014). Mitigation strategies of hydrogen sulfide emission in sewer networks - A review. *International Biodeterioration and Biodegradation*, *95*(PA), 251–261

Patel, S. K. S., Kumar, P., & Kalia, V. C. (2012). Enhancing biological hydrogen production through complementary microbial metabolisms. *International Journal of Hydrogen Energy*, *37*(14), 10590–10603.

Patel, S. K. S., Kumar, P., Singh, M., Lee, J. K., & Kalia, V. C. (2015). An integrative approach to producing hydrogen and polyhydroxybutyrate from biowaste using defined bacterial cultures. *Bioresource Technology*, *176*, 136–141.

Patel, S. K. S., Selvaraj, C., Mardina, P., Jeong, J. H., Kalia, V. C., Kang, Y. C., & Lee, J. K. (2016). Enhancement of methanol production from the synthetic gas mixture by *Methylosinus sporium* through covalent immobilization. *Applied Energy*, *171*, 383–391.

Patricia Giovanella, Luce´ lia Cabral, Fa´tima Bento, C. G. and F. A. O. C. (2016). Mercury (II) removal by resistant bacterial isolates and mercuric (II) reductase activity in a new strain of. *New Biotechnology*, *00*(00).

Peng, Y., He, Y., Wu, Z., Lu, J., & Li, C. (2014). Screening and optimization of low-cost medium for *Pseudomonas putida* Rs-198 culture using RSM. *Brazilian Journal of Microbiology*, *45*(4), 1229–1237.

Periago, P. M., Schaik, W. V., & Abee, T., Wouters, J. A. (2002). Identification of Proteins Involved in the Heat Stress Response of *Bacillus cereus* ATCC 14579. *Applied and Environmental Microbiology*, *68*(7), 3486–3495.

Periyasamy, M., & Rajan, M. (2009). Physico Chemical Characteristics and Water Quality Index of Electroplating Industry Effluent. *Journal of Industrial Pollution ControlControl Pollution*, *25*(1), 29–31.

Poblete-Castro, I., Becker, J., Dohnt, K., Santos, V. M. Dos, & Wittmann, C. (2012). Industrial biotechnology of *Pseudomonas putida* and related species. *Applied Microbiology and Biotechnology*, *93*(6), 2279–2290.

Pokorna, D., & Zabranska, J. (2015). Sulfur-oxidizing bacteria in environmental technology. *Biotechnology Advances*, *33*(6), 1246–1259.

Posada Uribe, L. F., Romero Tabarez, M., & Villegas Escobar, V. (2015). Effect of medium components and culture conditions in *Bacillus subtilis* EA-CB0575 spore production. *Bioprocess and Biosystems Engineering*, *38*(10), 1–10.

Pradesh, A. (2013). Determination of Water Quality Index in Industrial areas of Kakinada, *International Research Journal Environment Sciences*, *2*(5), 37–45.

Qambrani, N. A., & Oh, S. E. (2013). Effect of dissolved oxygen tension and agitation rates on sulfur-utilizing autotrophic denitrification: Batch tests. *Applied Biochemistry and Biotechnology*, *169*(1), 181–191.

Ramakrishna, G., & Susmita, M. (2012). Application of response surface methodology for optimization of Cr (III) and Cr (VI) adsorption on commercial activated carbons. *Research Journal of Chemical Sciences*, *2*(2), 40–48.

Ramos, I. Perez, R. Fdz-Polanco, M. (2013). Microaerobic desulphurization unit: A new biological system for the removal of H_2S from biogas. *Bioresource Technology*, *142*, 633–640.

Ranade, V. V., & Bhandari, V. M. (2014). Industrial Wastewater Treatment, Recycling, and Reuse: An Overview. In Butterworth-Heinemann (Ed.), *Industrial Wastewater Treatment, Recycling and Reuse* (First Edit, pp. 1–80). UK: Elsevier Ltd.

Rastegar, S. O., Mousavi, S. M., Shojaosadati, S. A., & Sheibani, S. (2011). Optimization of petroleum refinery effluent treatment in a UASB reactor using response surface methodology. *Journal of Hazardous Materials*, *197*, 26–32.

Rene, E. R., Veiga, M. C., & Kennes, C. (2012). Combined biological and physicochemical waste-gas cleaning techniques. *Journal of Environmental Science and Health - Part A Toxic/Hazardous Substances and Environmental Engineering*, *47*(7), 920–939.

Reshma, J. K., and Mathew, A. (2014). Biodegradation of Phenol-Aerobic and Anaerobic Pathways. *International Journal of Science and Nature*, *5*(3), 366–387.

Reverberi, A. Pietro, Klemeš, J. J., Varbanov, P. S., & Fabiano, B. (2016). A review of hydrogen production from hydrogen sulfide by chemical and photochemical methods. *Journal of Cleaner Production*, *136*, 72–80.

Ridzuan, N., Adam, F., & Yaacob, Z. (2016). Screening of factor influencing wax deposition using a full factorial experimental design. *Petroleum Science and Technology*, *34*(1), 84–90.

Robledo-Ortíz, J. R., Ramírez-Arreola, D. E., Pérez-Fonseca, A. A., Gómez, C., González-Reynoso, O., Ramos-Quirarte, J., & González-Núñez, R. (2011). Benzene, toluene, and o-xylene degradation by free and immobilized *P. putida* F1 of postconsumer agave-fiber/polymer foamed composites. *International Biodeterioration and Biodegradation*, *65*(3), 539–546.

Roebuck, K., Brundin, A., & Johns, M. (1995). Response surface optimization of temperature and pH for the growth of Pachysolen tannophilus. *Enzyme and Microbial Technology*, *17*(1), 75–78.

Roman, P., Lipińska, J., Bijmans, M. F. M., Sorokin, D. Y., Keesman, K. J., & Janssen, A. J. H. (2016). Inhibition of biological sulfide oxidation under haloalkaline conditions by thiols and Diorgano polysulfanes. *Water Research*, *101*, 448–456.

Roosta, A., Jahanmiri, A., Mowla, D., Niazi, A., & Sotoodeh, H. (2012). Optimization of biological sulfide removal in a CSTR bioreactor. *Bioprocess and Biosystems Engineering*, *35*(6), 1005–1010.

Rosen, A. Reactor Design, eBook 27 (2014).

Ross, T. (1996). Indices for performance evaluation of predictive models in food microbiology. *Journal of Applied Bacteriology*, *81*(5), 501–508.

Safitri, R., Priadie, B., Miranti, M., & Astuti, A. W. (2015). The ability of Bacterial Consortium: *Bacillus coagulans, Bacillus licheniformis, Bacillus pumilus, Bacillus subtilis , Nitrosomonas sp . and Pseudomonas putida* In Bioremediation of Wastewater. *AgriLife Scientific Journal* -, *4*(1).

Sahinkaya, E., Hasar, H., Kaksonen, A. H., & Rittmann, B. E. (2011). Performance of a sulfide-oxidizing, sulfur-producing membrane biofilm reactor treating sulfide-containing bioreactor effluent. *Environmental Science and Technology*, *45*(9), 4080–4087.

Salo, M. (2015). *Biological Sulfate Reduction and Recovery of Elemental Sulfur From Mining Waste Waters*.

Santos, A., Guimera, X., Dorado, A. D., Gamisans, X., & Gabriel, D. (2015). Conversion of chemical scrubbers to biotrickling filters for VOCs and H_2S treatment at low contact times. *Applied Microbiology and Biotechnology*, *99*(1), 67–76.

Sarti, A., Côrtes, R. S., Hirasawa, J. S., Pires, E. C., & Foresti, E. (2009). Post-treatment of effluents from the sulfate reduction process by anaerobic sequencing batch biofilm reactors. *Desalination*, *237*(1–3), 243–253.

Schultz, D., & Kishony, R. (2013). Optimization and control in bacterial lag phase. *BMC Biology*, *11*(1), 120.

Sekowska, A., Kung, H., & Danchin, A. (2000). Sulfur Metabolism in *Escherichia coli* and Related Bacteria : Facts and Fiction. *J. Mol. Microbiol. Biotechnol*, *2*(2), 145–177.

Shea, M., Litvin, S., & Chirnside, A. (2013). The Effect of Nitrogen, Sulfur, and Phosphorus Compounds on Bioremediation of Oil Spills by *Pseudomonas fluorescens* and *Bacillus subtilis*. *The Journal of Experimental Secondary Science*, 30–37.

Shuokr Qarani Aziz, and E. S. F. (2017). Optimization of Aeration Style and Cycle Time for Treatment of Oil Refinery Wastewater Using Powdered Activated... *Journal of Applied Research on Medicinal and Aromatic Plants*, (May).

Simpson, B., France, D., & Lewis, B. (2013). SESD Operating Procedure for Wastewater Sampling. *SpringerReference*.

Singh, K. P., Gupta, S., Singh, A. K., & Sinha, S. (2010). Experimental design and response surface modeling for optimization of Rhodamine B removal from water by magnetic nanocomposite. *Chemical Engineering Journal*, *165*(1), 151–160.

Singh, S. K., Singh, S. K., Tripathi, V. R., Khare, S. K., & Garg, S. K. (2011). Comparative one-factor-at-a-time, response surface (statistical) and bench-scale bioreactor level optimization of thermoalkaline protease production from a psychrotrophic *Pseudomonas putida* SKG-1 isolate. *Microbial Cell Factories*, *10*(1), 114.

Skrtic, L. (2006). Hydrogen Sulfide, Oil and Gas, and People's Health. *Energy*.

Sonawane, J. M., Marsili, E., & Chandra Ghosh, P. (2014). Treatment of domestic and distillery wastewater in high surface microbial fuel cells. *International Journal of Hydrogen Energy*, *39*(36), 21819–21827.

Srinivasan, V., Bhavan, P. S. and Krishnakumar, J. (2014). Bioremediation of Textile Dye Effluent By *Bacillus* and *Pseudomonas spp*. *International Journal of Science, Environment and Technology*, *3*(6), 2215–2224

Srivastava, S., Yadav, A., Seem, K., Mishra, S., Chaudhary, V., & Nautiyal, C. S. (2008). Effect of high temperature on *Pseudomonas putida* NBRI0987 biofilm formation and expression of stress sigma factor RpoS. *Current Microbiology*, *56*(5), 453–457.

Standbury, P.F., Whitaker, A. and Hall, S. J. (1984). P. of F. T. O. B. H. (1984). *The principle of Fermentation*. *Principles of Fermentation Technology*. *Oxford: Butterworth Heinemann* (2nd ed., Vol. 53). Oxford: Butterworth Heinemann.

Sumitha J and Sivakumar T. (2015). Optimization of Medium and its Components for Efficient Caffeine Degradation by Brevi Bacterium. *International Journal of Advanced Research in Engineering and Applied Sciences*, *4*(8), 29–37.

Sun, J., Dai, X., Liu, Y., Peng, L., & Ni, B. J. (2017). Sulfide removal and sulfur production in a membrane-aerated biofilm reactor: Model evaluation. *Chemical Engineering Journal*, *309*, 454–462.

Suresh Kumar, K., Dahms, H.-U., Won, E.-J., Lee, J.-S., & Shin, K.-H. (2015). Microalgae – A promising tool for heavy metal remediation. *Ecotoxicology and Environmental Safety*, *113*, 329–352.

Tandon, S. A., Shaikh, S., & Kumar, R. (2014). Development and use of soil bacterial consortia for bioremediation of dye polluted soil and municipal wastewater. *Global Journal of Bioscience and Biotechnology*, *3*(3), 284–291.

te Giffel, M. C., & Zwietering, M. H. (1999). Validation of predictive models describing the growth of Listeria monocytogenes. *International Journal of Food Microbiology*, *46*(2), 135–149.

Thomas, E. (2015). Microbial growth and physiology: A call for better craftsmanship. *Frontiers in Microbiology*, *6*(MAR), 1–12.

Ullhyan, A., & Ghosh, U. K. (2012). Biodegradation of phenol with immobilized *Pseudomonas putida* activated carbon packed bio-filter tower. *African Journal of Biotechnology*, *11*(85), 15160–15167.

Valdes, F., Camiloti, P. R., Rodriguez, R. P., Delforno, T. P., Carrillo-Reyes, J., Zaiat, M., & Jeison, D. (2016). Sulfide-oxidizing bacteria establishment in an innovative microaerobic reactor with an internal silicone membrane for sulfur recovery from wastewater. *Biodegradation*, *27*(2–3), 119–130.

Vinothini, C., Sudhhakar, S. and Ravikumar, R. (2015). Biodegradation of petroleum and crude oil by *Pseudomonas putida* and *Bacillus cereus*. *International Journal of Current Microbiology and Applied Sciences*, *4*(1), 318–329.

Wang, A., Liu, C., Ren, N., Han, H., & Lee, D. (2010). Simultaneous removal of sulfide, nitrate, and acetate: Kinetic Modeling. *Journal of Hazardous Materials*, *178*(1–3), 35–41.

Wang, C., Stanciu, C., Ehrhardt, C. J., & Yadavalli, V. K. (2015). Morphological and mechanical imaging of *Bacillus cereus* spore formation at the nanoscale. *Journal of Microscopy*, *258*(1), 49–58.

Wang, L. K., Shammas, N. K., & Hung, Y.-T. (2009). *Advanced Biological Treatment Processes*. Humana Press.

Wang, X., Zhang, Y., Zhou, J., Zhang, T., & Chen, M. (2015). Regeneration of elemental sulfur in a simultaneous sulfide and nitrate removal reactor under different dissolved oxygen conditions. *Bioresource Technology*, *182*(x), 75–81.

Watsuntorn, W., Ruangchainikom, C., Rene, E. R., Lens, P. N. L., & Chulalaksananukul, W. (2017). Hydrogen sulfide oxidation under anoxic conditions by a nitrate-reducing, a sulfide-oxidizing bacterium isolated from the Mae Um Long Luang hot spring, Thailand. *International Biodeterioration and Biodegradation*, *124*, 196–205.

Wei ZS, Ye QH, Li BR, C. Z. and H. Q. (2015). Removal of Dimethyl Sulphide in a Biotrickling Filter under Thermophilic Conditions. *Journal of Bioremediation & Biodegradation*, *06*(06).

WHO. (2003). *Total dissolved solids in Drinking-water: Background document for development of WHO Guidelines for Drinking-water Quality*. *Health criteria and other supporting information* (2nd ed., Vol. 2).

Xia, Y., Lü, C., Hou, N., Xin, Y., Liu, J., Liu, H., & Xun, L. (2017). Sulfide production and oxidation by heterotrophic bacteria under aerobic conditions. *ISME Journal*, *11*(12), 2754–2766.

Xiaowei Wang, Yu Zhang, Tinting Zhang, J. Z. (2016). Effect of dissolved oxygen on elemental sulfur generation in sulfide and nitrate removal process: characterization, pathway, and microbial community analysis. *Applied Microbiology and Biotechnology*, *100*(2895–2905), 1–11.

Xin-hui, D., Srinivasakannan, C., Qu, W. W., Xin, W., Jin-hui, P., & Li-bo, Z. (2012). Regeneration of microwave assisted spent activated carbon: Process optimization, adsorption isotherms, and kinetics. *Chemical Engineering and Processing: Process Intensification*, *53*, 53–62.

Xu, S., Huang, S., Guo, D., Zhao, Y., & Song, M. (2017). Failure analysis of a carbon steel pipeline exposed to wet hydrogen sulfide environment. *Engineering Failure Analysis*, *71*, 1–10.

Xu, X., Chen, C., Wang, A., Guo, W., Zhou, X., Lee, D. J., Ren, N., Chang, J. S. (2014). Simultaneous removal of sulfide, nitrate, and acetate under denitrifying sulfide removal condition: Modeling and experimental validation. *Journal of Hazardous Materials*, *264*, 16–24.

Yang, Q., Xiong, P., Ding, P., Chu, L., & Wang, J. (2015). Treatment of petrochemical wastewater by microaerobic hydrolysis and anoxic/oxic processes and analysis of bacterial diversity. *Bioresource Technology*, *196*, 169–175.

Ye, Y. Feng, Li, Q. Qin, Fu, G., Yuan, G. qing, Miao, J. Hua, & Lin, W. (2012). Identification of Antifungal Substance (Iturin A2) Produced by *Bacillus subtilis* B47 and Its Effect on Southern Corn Leaf Blight. *Journal of Integrative Agriculture*, *11*(1), 90–99.

Zainol, N., Arif, A., Zaki, B. M., Hidayah, N., Yasin, M., Rahman, S. A., Aziz, A., Yee, S. C. (2017). Factorial Analysis of Sulfide Removal from Petrochemical Industry Wastewater using Acclimatized Activated Sludge. *MATEC Web of Conferences*, *02001*(111), 1–4.

Zainol, N., Faiz, M., Ameen, M., & Rahman, S. A. (2017). Factorial Analysis of Processing Factors for Nitrogen, Phosphorus and Potassium Contents in Mushroom Waste. *Journal of Chemical Engineering and Industrial Biotechnology*, *1*(1), 42–56.

Zamani, M. M., Mortazavi, S. H., Aligholi, M., Mahmoud Janlou, H., Khodi Aghmiuni, S., Pormasjedi-Meibod, M. S., Ghanadian, N., Azin, M., Khansari, M. G. (2012). Native Bacterial Mixed Culture: A Proportionate Solution for Refinery and Petrochemical Wastewaters. *Thrita Journal of Medical Sciences*, *1*(4), 149–154.

Zhang, B., Zhang, J., Liu, Y., Hao, C., Tian, C., Feng, C., Lei, Z., Huan, W., Zhang, Z. (2013). Identification of removal principles and involved bacteria in microbial fuel cells for sulfide removal and electricity generation. *International Journal of Hydrogen Energy*, *38*(33), 14348–14355.

Zhang, L., De Schryver, P., De Gusseme, B., De Muynck, W., Boon, N., & Verstraete, W. (2008). Chemical and biological technologies for hydrogen sulfide emission control in sewer systems: A review. *Water Research*, *42*(1–2), 1–12.

Zhang, Q., Hu, J., & Lee, D. J. (2016). Microbial fuel cells as pollutant treatment units: Research updates. *Bioresource Technology*, *217*, 121–128.

Zhishu Liang, Taicheng An, Guiying Li, Z. Z. (2015). Aerobic biodegradation of odorous dimethyl disulfide in an aqueous medium by isolated *Bacillus cereus* GIGAN2 and identification of transformation intermediates. *Bioresource Technology*, *175*, 563–568.

Zhou, W. W., He, Y. L., Niu, T. G., & Zhong, J. J. (2010). Optimization of fermentation conditions for production of anti-TMV extracellular ribonuclease by *Bacillus cereus* using response surface methodology. *Bioprocess and Biosystems Engineering*, *33*(6), 657–663.

Ziaei, S. M. R., Kokabi, A. H., & Nasr-Esfehani, M. (2013). Sulfide stress corrosion cracking and hydrogen induced cracking of A216-WCC wellhead flow control valve body. *Case Studies in Engineering Failure Analysis*, *1*(3), 223–234.

Zytoon, M. A.-M., AlZahrani, A. A., Noweir, M. H., & El-Marakby, F. A. (2014). Bioconversion of high concentrations of hydrogen sulfide to elemental sulfur in airlift bioreactor. *Hindawi Publishing Corporation; The Scientific World Journal*, *2014*, 675673.

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